pumps, and auxiliary condensers, and pumps for the auxiliary machinery. The torpedo outfit for auto-mobile torpedoes, probably of the Howell type, will consist of six launching-tubes, — one forward, another aft, and two on each broadside, — and in addition there will be the usual outfit of boat torpedoes. The rig is that of a two-masted schooner of small sail area, steam being the motive power on which the main dependence will be placed. The cost of these cruisers will be $700,000 each. The bids for them will be opened in August next.

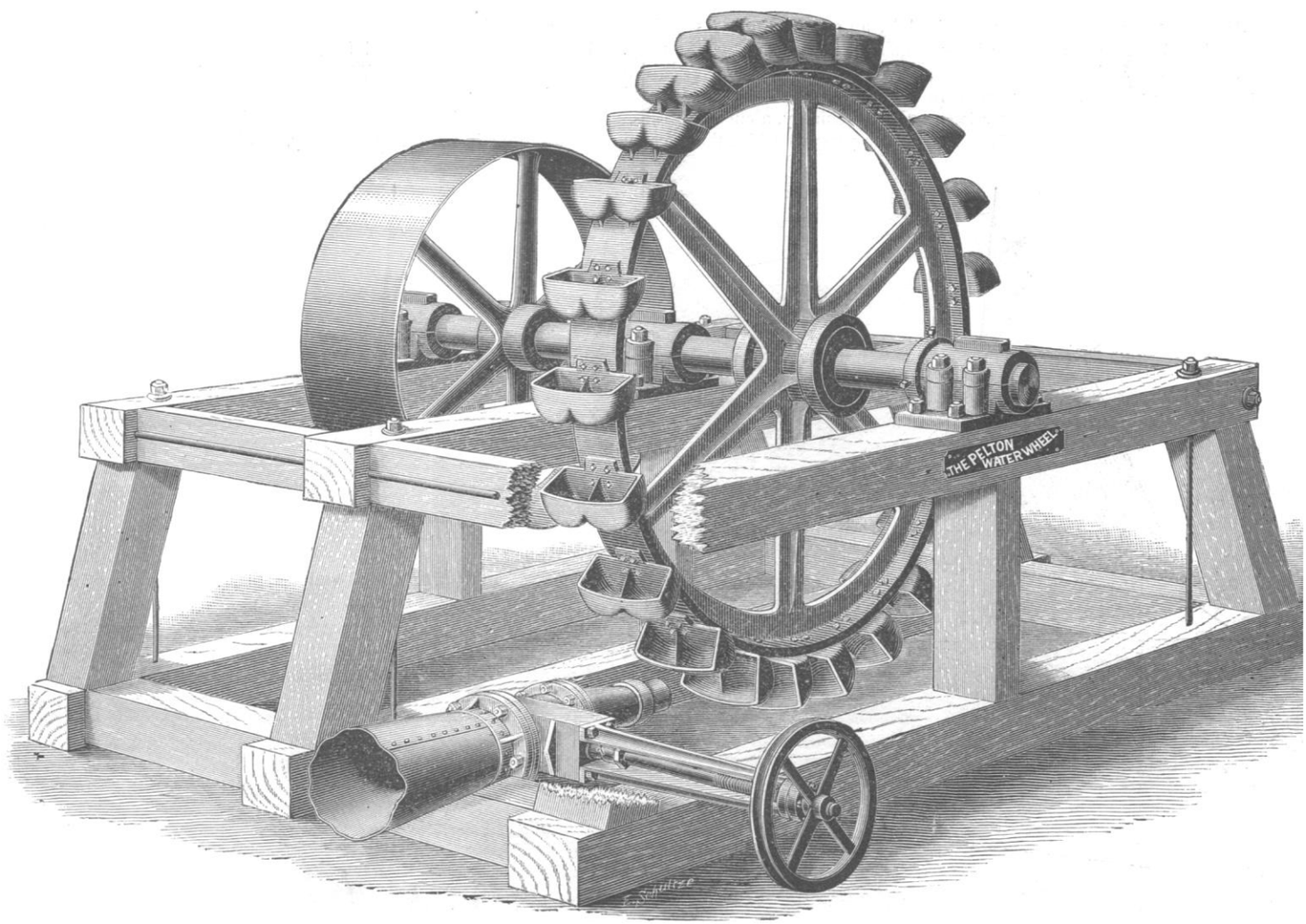
ELECTRICAL POWER TRANSMISSION AT VIRGINIA CITY, NEV.

"MORE power, economical power," has now for several years been the imperative demand of the owners of mining properties on the celebrated Comstock Lode at Virginia City. The problem has been to work the enormous quantities of low-grade ore at a profit. Large sums have been expended in carrying water from streams in the neighboring Sierra Nevada Mountains for a distance of some thirty miles, to be utilized at the mines and mills on the Comstock. But this supply of water is limited and variable, and by no means meets the demand. Operations have frequently been suspended on this account, causing great loss to the mine-owners, and hardship to the laborers dependent upon the active working of the ores.

The best engineering talent of the country has been called to work on this vital problem of power-supply, and new arrangements have been made for increasing the amount of water; but vast powers now within reasonable range are still running to waste, which the use of electricity alone can conserve.

At the stamp-mill of the Nevada Mill and Mining Company, water-power was obtained at the level of the mill from a reservoir on the side of the mountain. The mill contains 60 stamps, with their complement of pans, settlers, agitators, rock-breakers, etc. The water-power readily available was entirely inadequate for the operation of the mill.

The problem was submitted to the Brush Electric Company through its agents, the California Electric Light Company of San Francisco. A solution was speedily offered, and the plans were accepted by the owners of the Nevada Mill and Chollar Mine. The shaft of the latter is close to the stamp-mill. It was proposed to collect the waste water from the surface wheel at the mill, convey it in pipes to the shaft of the Chollar Mine, and thence down the shaft until a sufficient head should be obtained to produce the power required. The scheme was novel, and presented many difficulties. However, experts pronounced the plans feasible, and work was begun last winter.

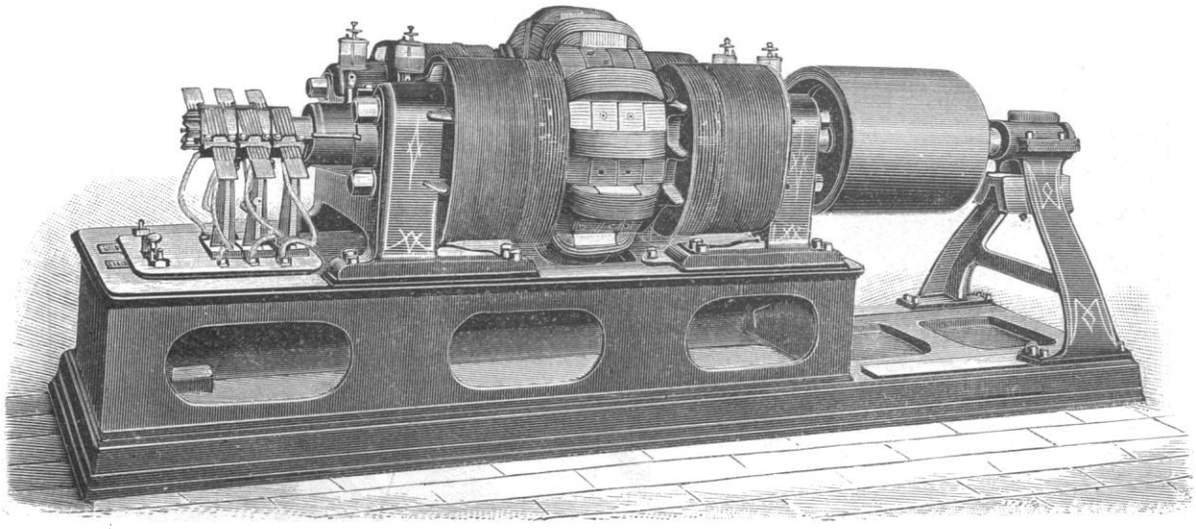


THE PELTON WATER-WHEEL USED UNDER 1680 FEET HEAD IN THE CHOLLAR MINE.

At the 1,650-foot level of the Chollar Mine a subterranean chamber was excavated out of solid porphyry for the reception of the dynamo electric generators and water-wheels. This chamber is 50 feet in length by 25 feet in width, and 12 feet in height, clear of all timbers. From the tank containing the waste surface water, two wrought-iron pipes are led to the subterranean chamber, one 10 and one 8 inches in diameter. At the bottom of the shaft a Y unites these two pipes into a single one 14 inches in diameter, out of which six 6-inch pipes run to the nozzles of the water-wheels provided to drive the large Brush dynamo electric generator.

The underground electrical station is of the most interesting character, and is shown in our illustrations. The large Brush pri-

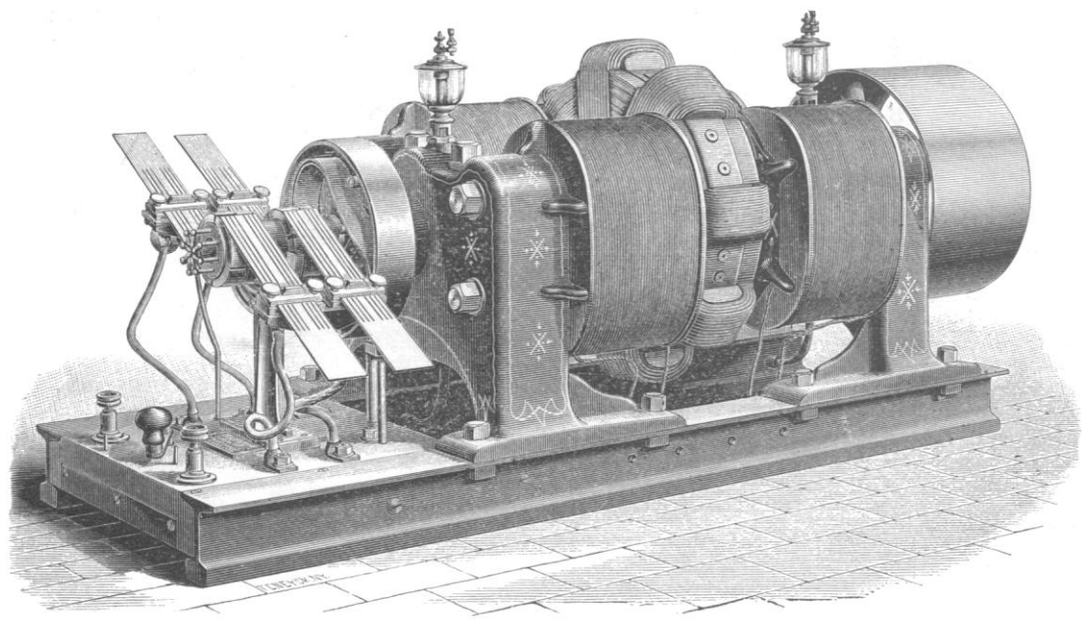
mary generators, of which there are six, are adapted to the conditions by a few mechanical changes from the standard pattern. They are mounted on a heavy cast-iron base, and are provided with an extended shaft and outer bearing. On the armature shaft, and between two bearings, the Pelton wheel is mounted and enclosed in a water-tight cover. The cut of the generator is made from a photograph taken at the Brush Electric Company's works at Cleveland, before shipment, and shows a pulley on the armature shaft, arranged for testing-runs at the factory. The water-wheel is attached to the armature shaft at the place occupied by this pulley, and a coupling is provided for detaching this entire end of the shaft carrying the wheel from the other end carrying the armature.



BRUSH DYNAMO, CHOLLAR MINE.

These Brush generators are each of 130-horse-power capacity, and are compound wound for constant current. The electrical curve from these machines is almost ideally perfect, and they require no regulator whatever. The current remains of constant strength under all conditions of load.

The head of water at the underground chamber is 1,680 feet. It has never before been attempted to run a water-wheel under such enormous pressure. This was indeed one of the most serious problems involved in this remarkable installation. From the various excellent forms of water-wheels, the Pelton was selected as best adapted to work under the special circumstances. This wheel is the outgrowth of the old hurdy-gurdy form, and, as will be seen from the illustration, its buckets are provided with a very ingenious wedge-shaped partition, by which the stream of water is divided, and sweeps out through the curved sides in such a way as to produce a re-actionary effect in addition to the impact. By the peculiar construction of the buckets, all the water is also thrown down and out of the way of the wheel. The six Pelton wheels are each 40 inches in diameter, are made of phosphor-bronze, and weigh 220 pounds. They drive the generators at the rate of 900 revolutions per minute. The compact arrangement of combined dynamo generator and water-wheel makes it almost impossible for the visitor to the underground chamber to realize the enormous amount of power here at work. The machines are placed in parallel rows of three, and the swift-revolving armatures are all that can be seen in motion as evidence of the 800 horse-power generated. The chamber is brilliantly lighted by 36 Swan incandescent lamps, operated in multiple series from one of the Brush generators, and there are several of the same lamps in the incline. Each generator circuit is provided with a dead-beat ammeter of the Brush pattern; and a Brush voltmeter is also at hand, which is

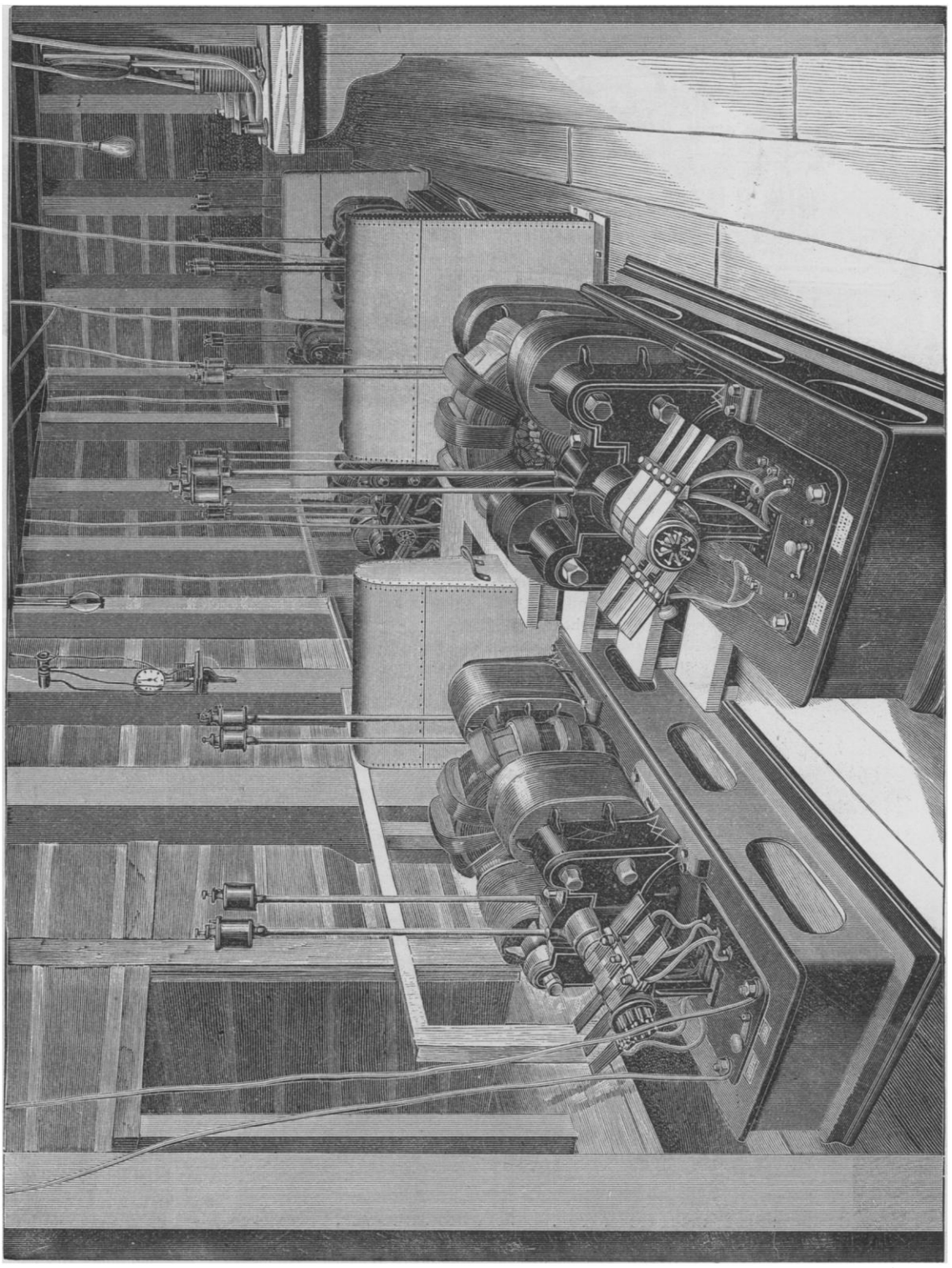


BRUSH ELECTRIC MOTOR, EIGHTY HORSE-POWER, NEVADA MILL.

capable of measuring up to 3,000 volts. The generator circuits are led to a switch-board in the same dynamo-room, where any generator can be thrown on to any one of the outgoing motor circuits.

Leaving this subterranean power station, and ascending the Chollar shaft, are the circuits of copper wire, one to each generator. At one point these circuit wires pass through a shower-bath of spray, but the insulation is so perfect that no leakage has yet developed. The wires issue from the mine shaft, and are carried above ground to the electric-motor room at the Nevada Mill. The total length of each circuit is a little more than a mile.

The electric-motor room is shown in one of the large illustrations. The six motors are of the regular Brush constant-current type, each of 80-horse-power capacity, and are arranged in a single row parallel with the main driven shaft, to which they are all belted in the ordinary manner. The surface water-wheel is also connected to this same shaft. It will be noted that there is here a very novel and interesting feature. This surface wheel uses the water in the first instance, and furnishes part of the power to drive the main shaft. The waste water, after this primary use, is carried down the Chollar shaft to the underground chamber, where it drives the dynamos which generate the electric current and ener-

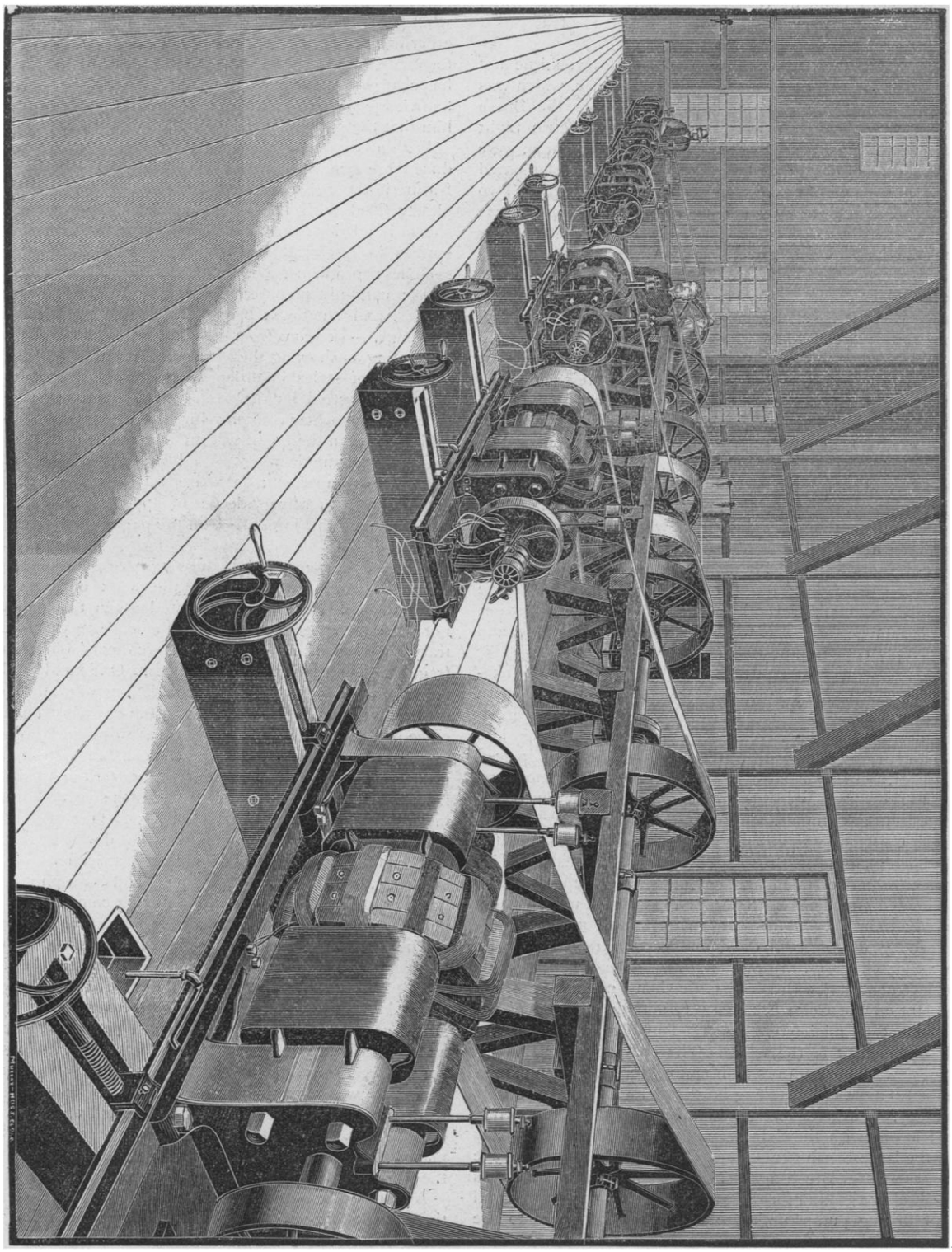


UNDERGROUND BRUSH POWER STATION AT THE 1650-FOOT LEVEL OF THE CHOLLAR MINE.

gize the electric motors above ground, which in turn furnish additional power to the main shaft.

Each electric motor has its own independent circuit fed from one of the generators. The well-known Brush centrifugal governor, with which each motor is fitted, regulates the speed sensitively, and all or any number of the motors work perfectly in a battery together or with the water-wheel. In the motor-room there is also an ammeter for each electric motor, to show at all times the current flowing in each circuit. The motors run at a speed of 850 revolutions per minute. Some difficulty was anticipated in operating the motors together on one shaft in the manner described, but none was encountered. The motors have not given a moment's trouble or annoyance of any kind from the start.

Some idea of the economic value of this electric power plant to the mine-owners may be got from a statement of the saving effected by it. The surface wheel alone requires 312 miner's inches of water to develop power sufficient to drive 40 of the 60 stamps with which the mill is equipped. Moreover, this amount of water is seldom available. Two of the electric motors, working in addition to the surface wheel, will perform the same service with but 72 miner's inches of water, thus effecting a saving of about 77 per cent.



BRUSH MOTOR-ROOM AT NEVADA MILL.

The net commercial efficiency of the plant, taking into account all elements of loss, including that in the conducting wires, is about 70 per cent: in other words, 70 per cent of the power applied to the shafts of the generators in the underground chamber is delivered for work at the main line shaft in the mill.

The waste water from the 1,650-foot level of the Chollar Mine is piped into the Sutro Tunnel. It is now proposed to use this water a third time at a lower level for other work, by means of a similar application of electrical machinery.

It was expected at the outset that many difficulties would be met in an installation of such novel and original character, which was also by far the largest ever attempted. The projectors, the Brush Electric Company and their agents, the California Electric Light Company, who assumed charge of the details of the erection, were very greatly pleased to find that their forethought had eliminated the troubles anticipated and predicted in almost all respects. Two purely technical difficulties were encountered when the plant was started experimentally, which caused some delay and anxiety. They were, first, the lack of any governing appliance for the water-wheels; and, second, the damage to the primary generators caused by the extreme heat and dampness in the underground station.

The Brush Electric Company, in its original plans and specifications, stipulated that the water-wheel should be governed within reasonable limits; but this requirement was not met, and the first generator and motor, started up experimentally, showed the necessity of this provision. The Brush Company was surprised to receive by telegraph the first intimation that the makers of the water-wheels had wholly neglected such an important matter, but was fortunately able to close the breach at once. A water-wheel governor, invented and sketched out by Mr. W. B. Devereux, the prominent mining engineer, of Aspen, Col., had been placed in the hands of the company some time previously, and working drawings of it had been made at Cleveland. These were at once sent to California, the governors were quickly made, and this source of trouble was overcome. Mr. F. E. Smith, the electrical engineer in charge of the installation, made several modifications of the governor, after watching its performance, which proved of much value, and it has worked perfectly in practical service.

The second difficulty was met with equal promptness, and likewise entirely overcome. The temperature of the subterranean power chamber is about 72° F. The atmosphere is almost saturated with moisture, — 78 per cent. Any piece of metal taken into it begins immediately to "sweat." The generators, when placed in this chamber, were soon covered and saturated with moisture, and began to show leaks, while the motors above ground were absolutely free from any trouble.

The Brush Company was at once notified of this unanticipated source of difficulty, and Mr. Brush speedily devised a method of insulation which would certainly and completely resist the moisture of the sublimated atmosphere. Since its application the generators have worked admirably, and the entire plant is now at work regularly, performing its expected duty, and economizing the power available, as stated above.

The achievement of the Brush Electric Company, in connection with this plant on the Comstock, is a very notable one, and of the greatest interest to mining engineers. The plant is the largest electrical power plant in the world. The company is making a specialty of powerful generators and motors for power transmission and distribution, and is taking large orders for them, not only in this country, but also for foreign shipments. The latest contract announced is one with the Calumet and Hecla Mining Company for five of the large Brush generators of 130 horse-power, and five of the 80 horse-power Brush motors. A power station will in this case be built above ground for the generators, and the motors will be used for driving pumps underground. The plant goes to the copper-mine at Calumet, Mich.

A MODEL SCHOOL OF ARCHITECTURE.

THE department of architecture of Columbia College has closed its work for the year with its annual exhibition of drawings. This department was organized eight years ago largely through the liberality of Mr. F. A. Schermerhorn, who contributed the necessary funds to place it on a firm basis. It has grown with unusual rapidity, and is now one of the strongest parts of the School of Mines of Columbia College. During the past year, sixty-five students were registered in the department, an increase of twenty-five over the preceding year. The money furnished by Mr. Schermerhorn has enabled the trustees to supply a liberal collection of apparatus, models, books, photographs, and drawings; and the whole forms a collection of working material not equalled by another institution of the same kind in the country. Columbia is fortunate, also, in possessing in Professor William R. Ware, who has charge of this course, a teacher who combines sound technical knowledge with a warm sense of architectural form, and it is to him that the success of this school of architecture is chiefly due.

With a large body of students it is, of course, possible to produce large quantities of work, and this was the first noticeable feature in the recent exhibition. Four or five rooms were completely filled with the work of the students. Specimens were shown in all departments of architectural drawing. There were studies in historical ornament, many of them highly spirited sketches; problems, with details and perspectives; original designs; carefully prepared elevations; studies in perspective, in shades, and shadows; pencil drawings from the cast; memory drawings, — sketches from descriptions of photographs, and highly interesting as showing the attention that must have been given to the study of styles in order to produce such results; free-hand sketches of actual buildings and from photographs; applications of design and water colors. Nor was the quality of the work less noticeable than the quantity. In a collection of the work of an entire year, some drawings would be necessarily included that are more or less imperfect; but there were few of these, and they all evinced an extraordinary degree of application on the part of the students, and untiring energy on the part of the teachers and instructors.

Many of the pen-and-ink drawings were exquisitely done, and compared very favorably with the work of more experienced draughtsmen. The work of the students in this department does not cease with the conclusion of the college year. On the contrary, they are encouraged to enter architects' offices, and to make frequent sketches during the summer. One hundred drawings are required to be handed in at the beginning of the college year as evidences of summer work, though each day passed in an architect's office is accepted as the equivalent for a drawing. The hand and mind of the student are thus kept in constant practice, and there is no doubt but that much of the superior work in this school arises from the fact that the work is constant the year round, and is not interrupted by three months of idleness. One of the most interesting sections of the exhibition was that devoted to summer work. The exhibit was large, and included specimens of all kinds of drawings, both from actual buildings and from photographs. The quality of the subjects was an interesting commentary on the manner in which the tastes of these young men had been trained.

The problems of execution included a staircase, with perspective and detail drawings, elevation and details of a classical window, and several other subjects. All these were class-work, and were marked with the criticisms of the professor. Another interesting series were designs for a wrought-iron gate, and some studies for a Roman villa, by the first-year students. Space does not permit, nor is it necessary, to enumerate all the drawings shown. The exhibition was one to have been seen to be appreciated. The work was characterized not only by marked ability on the part of the students, but also testified to the great care and thought displayed by the teachers. The drawings showed an enthusiasm for the work which is not always to be found among undergraduates.

A word as to methods. The course in architecture extends over three of the four years' course in the School of Mines. The first college year is devoted by all the students to general studies; but in the second year the class is divided into sections, each pursuing a technical study. In the course in architecture, drawing is an important feature throughout the three years. In the first year the elements of architecture, with the forms and proportions of the five orders, are taught, together with the study of Greek and Roman architectural history. In the second year technical studies in the mechanics of solids are introduced, and a survey made of the ma-